rat. In its electrophysiological characteristics and distribution, this pontine wave is similar to the PGO wave of the cat. Additional research in this laboratory (*11*) has shown that the administration of *dl*-parachlorophenylalanine (PCPA) as well as REM sleep deprivation have effects in the rat similar to the effects of these manipulations on the distribution of PGO waves in the cat (*4, 5, 12*). We suggest that the pontine phasic wave in the albino rat, like the PGO wave in the cat, is an electrophysiological expression of REM sleep central phasic brainstem activity.

The general process represented by PGO activity, that is, the generation in the pons of central phasic discharge in REM sleep (combined with its ascending and descending transmissions), consists of a complex set of relationships in which systems other than the visual also appear to participate. It has already been shown that auditory structures in the cat and human display phasic discharge during REM sleep in a manner similar to the discharge in the visual system (*13*). We believe that the pontine waves recorded in the albino rat represent this fundamental REM sleep process of central phasic activation. Further exploration for reflections of REM sleep phasic stimulation may yield positive results in structures of highly utilized sensorimotor systems (for example, the olfactory system). That the nucleus locus ceruleus—which in the rat (i) provides noradrenergic innervation to vast areas of the brain (*14*), (ii) participates in the mediation of waking functions (such as learning, positive reinforcement, hippocampal orienting responses) (*15*), and (iii) may play a role in neuronal maturation (*16*)—is a REM sleep phasic activity site supports the hypothesis that brain regions subserving highly relied upon functions are invested with phasic activation during REM sleep.

The extensive use of the albino rat in sleep experiments has been limited by the unavailability of an important variable—REM sleep central phasic activity. The findings reported here may have the additional practical value of establishing this relatively convenient and inexpensive laboratory animal as an appropriate subject for electrophysiological and pharmacological studies of sleep and phasic activity.

JORGE FARBER
GERALD A. MARKS
HOWARD P. ROFFWARG
Department of Psychiatry,
Southwestern Medical School,
University of Texas,
Dallas 75235

References and Notes

1. D. C. Brooks and E. Bizzi, *Arch. Ital. Biol.* **101**, 648 (1963).
2. E. Bizzi and D. C. Brooks, *ibid.*, p. 666; J. Calvet, M. C. Calvet, J. M. Langlois, *J. Neurophysiol.* **28**, 893 (1965); J. A. Hobson, *Soc. Biol.* **158**, 2131 (1964); T. M. Mikiten, P. H. Diebyl, C. D. Hendley, *Fed. Proc. Fed. Am. Soc. Exp. Biol.* **20**, 327 (1961); J. Mouret, M. Jeannerod, M. Jouvet, *J. Physiol.* (*Paris*) **55**, 305 (1963); A. A. Perachio, *Sleep Res.* **2**, 42 (1973); E. D. Weitzman, *Arch. Neurol.* **12**, 463 (1965).
3. R. W. McCarley, J. P. Nelson, J. A. Hobson, *Science* **201**, 269 (1978); H. Saito, K. Sakai, M. Jouvet, *Brain Res.* **134**, 59 (1977); M. Jouvet, *Ergeb. Physiol. Biol. Chem. Exp. Pharmakol.* **64**, 166 (1972).
4. W. C. Dement, in *Sleep: An Active Process*, W. B. Webb, Ed. (Scott, Foresman, Glenview, Ill., 1973), p. 33.
5. J. Ferguson and W. Dement, *Psychophysiology* **4**, 380 (1968); J. Ferguson *et al.*, *ibid.* **5**, 238 (1968).
6. C. Gottesmann, *Physiol. Behav.* **4**, 495 (1969).
7. W. Stern, W. Forbes, P. Morgane, *ibid.* **12**, 293 (1974).
8. R. D. Lund, *Science* **149**, 1506 (1965); R. W. Guillery, *Sci. Am.* **230**, 44 (May 1974).
9. The two kinds of pontine wave presentation in the rat—single waves and bursts—are reminiscent of the two kinds of PGO activity in the cat recorded in the lateral geniculate body: Type I waves—isolated potentials found throughout REM sleep as well as in the SW sleep segments before the onset of REM sleep, and Type II waves—PGO bursts, always related to clusters of eye movements [A. R. Morrison and O. Pompeiano, *Arch. Ital. Biol.* **104**, 425 (1966)].
10. Sixty-five percent of the artifact-free awake time was associated with physical activity and scored as active wakefulness; 88 percent of the awake waves were found in this stage of activity. Of these, 85 percent were accompanied by eye movements, though the vast majority of eye movements in the active waking state were not associated with phasic pontine waves. The remaining 12 percent of awake phasic waves appeared in the 35 percent of awake scored as quiet wakefulness; of these approximately 40 percent were associated with eye movements.
11. G. A. Marks, J. Farber, M. Rubinstein, H. P. Roffwarg, *Exp. Neurol.*, in press.
12. F. Delorme, J. Froment, M. Jouvet, *C. R. Seances Soc. Biol. Paris* **160**, 2347 (1966); W. P. Koella, A. Feldstein, J. S. Czicman, *Electroencephalogr. Clin. Neurophysiol.* **25**, 481 (1968); P. Vimont-Vicaray, D. Jouvet-Mounier, F. Delorme, *ibid.* **20**, 439 (1966).
13. M. Pessah and H. P. Roffwarg, *Science* **178**, 773 (1972); H. P. Roffwarg, J. Adrian, G. Marks, J. Farber, *Sleep Res.* **8**, 35 (1980).
14. U. Ungerstedt, *Acta Physiol. Scand. Suppl.* **367** (1971); O. Lindvall and A. Bjorklund *ibid.* **412** (1974); M. Palkovits and D. M. Jacobowitz, *J. Comp. Neurol.* **157**, 29 (1974).
15. G. M. Anlezark, T. J. Crow, A. P. Greenway, *Science* **181**, 682 (1973); T. J. Crow, P. J. Spear, G. W. Arbuthnott, *Brain Res.* **36**, 275 (1972); J. Farber, S. J. Ellman, L. A. Mattiace, A. Holtzman, P. Ippolito, R. Halperin, S. S. Steiner, *ibid.* **112**, 148 (1976); M. Segal and F. E. Bloom, *ibid.* **107**, 513 (1976); S. Ritter and L. Stein, *J. Comp. Physiol. Psychol.* **85**, 443 (1973); S. J. Ellman, R. F. Ackermann, J. Farber, L. A. Mattiace, S. S. Steiner, *Physiol. Psychol.* **2**, 31 (1974); D. G. Amaral and H. M. Sinnamon, *Prog. Neurobiol.* **9**, 147 (1977).
16. T. Maeda, M. Tohyama, N. Shimizu, *Brain Res.* **70**, 515 (1974).

17. We thank M. Rubinstein for technical assistance. Supported by grants 31420 and 06418 from National Institute of Mental Health and an Alfred P. Sloan research fellowship.

25 October 1979; revised 10 March 1980

Disruptive Coloration in Butterflies: Lack of Support in *Anartia fatima*

Abstract. *Experimental obliteration of high-contrast wing stripes of the neotropical butterfly* Anartia fatima *affected neither survival nor wing damage in a natural population over a 5-month period. There is no direct evidence supporting the hypothesis that so-called disruptive wing patterns function as protective coloration in butterflies.*

"Disruptive" color patterns, consisting of high-contrast markings that serve to break up the outline of an organism, are among the classical types of protective coloration common in the animal kingdom (*1*). Such patterns presumably protect their bearers by fragmenting the visual image into smaller units, by producing a conflicting outline that obscures essential body features, and/or by delimiting target areas that may direct attacks by predators away from vital organs. By whatever mechanisms they operate, disruptive patterns ought to improve the chances of survival of individuals bearing them, relative to concolorous individuals. We now report the results of a field experiment designed to measure directly the effectiveness of disruptive coloration in a butterfly.

Table 1. Longevity measured as difference between first and last captures (*6*).

Minimum age (weeks)	Experimental (No.)	Treated control* (No.)
0	37	38
1	24	26
2	20	25
3	9	6
4	6	1
5	1	1
Total	97	97

*Kolmogorov-Smirnov test: $D = 0.082$; $P > .10$.

The butterfly *Anartia fatima* (Lepidoptera: Nymphalidae) (Fig. 1) is commonly found in disturbed habitats throughout Central America (*2-4*). We studied the small, insular population located on Barro Colorado Island, Panama, from April through August 1978. Since *A. fatima* frequented only the disturbed site at the laboratory clearing, it was possible to capture and individually mark (*5*) nearly the entire population. Recapture rates were extremely high, often with many recaptures per individual. Hence it was possible to determine the minimum age of each butterfly at every capture and a minimum longevity for each individual in the population (*6*); in addition, indirect indices and models were used to estimate population size (*7*). Besides noting the sex and general features of each butterfly, several measures of condition were made for capture, including general condition of the butterfly as a whole (*8*) and a coded measure of wing damage (*9*).

Experimental modification consisted of obliteration of the characteristic vertical wing stripes by applying black felt-tip marking pens to them. A control group was similarly modified, but with the dye applied to the dark region just basal to the light stripe, so that the appearance of the butterfly remained unchanged (Fig. 1D). Individuals selected for the experiment during each sampling period were newly captured males that were in good or excellent condition and without significant wing damage (*10*). Equal numbers of new experimental and control individuals were released after each sampling period, in addition to those recaptured. Sampling was done weekly and lasted for 3 hours, so that the butterflies were subject to natural predation under field conditions for more than 90 percent of their lives.

Table 2. General condition of individuals in excellent condition at first capture.

Condition	Experimental					Control				
	Excellent	Good	Fair	Poor	Disappear	Excellent	Good	Fair	Poor	Disappear
				Number of transition events						
Excellent	0	41	15	0	37	0	36	14	2	38
Good		4	14	11	17		2	16	2	17
Fair			6	9	21			0	10	20
Poor				10	21				2	18
				Frequencies						
Excellent	0	0.45	0.16	0	0.39	0	0.40	0.16	0.02	0.42
Good		0.09	0.30	0.24	0.37		0.05	0.43	0.05	0.47
Fair			0.17	0.25	0.58			0	0.33	0.67
Poor				0.32	0.68				0.10	0.90
Individuals					96					93
Transitions					206					177

Table 3. Wing damage (*9*, *10*) as related to age (*6*).

Age at capture (week)	Last week in which wings were intact*				New symmetrical damage since last capture†			
	Experimental		Control		Experimental		Control	
	N	Percent	*N*	Percent	*N*	Percent	*N*	Percent
0	81	83.5	88	90.7				
1	14	14.4	6	6.2	18	39.1	19	46.3
2	2	2.1	2	2.1	11	23.9	16	39.0
3	0	0.0	1	1.0	12	26.1	4	9.8
4	0	0.0	0	0.0	4	8.7	1	2.4
5	0	0.0	0	0.0	1	2.2	1	2.4
Total	97		97		46		41	

*Kolmogorov-Smirnov test: $D = 0.072$; $P >> .10$. †$D = 0.223$; $P > .10$.

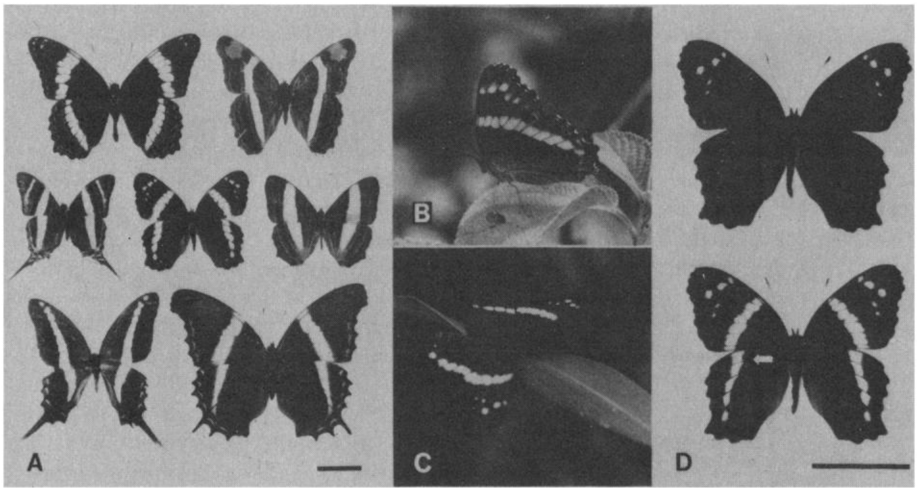

Fig. 1. (A) A diverse assemblage of butterflies having "disruptive" stripe patterns. Clockwise from upper left: *Limenitis a. arthemis* Drury (New Hampshire, U.S.A.), *Adelpha fessonia* Hewitson (Mexico), *Cyrestis acilia* Godart (New Guinea), *Siproeta superba* Bates (Guatemala), *Graphium kirbyi* Hewitson (Kenya), *Marpesia orsilochus* Fabricius (Venezuela), *Anartia fatima* Fabricius (Panama; center). Scale bar, 2 cm. (B and C) Living *A. fatima* on Barro Colorado Island, Panama, showing the conspicuous display of the striped pattern when the butterfly is at rest, with wings both closed (B) and open (C). (D) Experimental (top) and treated control (bottom) *A. fatima*. Arrow indicates location of treatment (black stripe) on control. Scale bar, 2 cm.

Results of this experiment were clear-cut and unexpected. Over the 21-week period of the study, butterflies in the experimental group lacking disruptive coloration lived as long as butterflies in the control group (Table 1).

The experimental group did at least as well as the control group in all measures used. The two groups did not differ in frequencies of transitions of general condition over 1-week intervals (Table 2), nor in the frequencies of intact wings, symmetrical damage [(*9*) and Table 3], or types of damage to the wings. These results indicate no difference in the manner of attack or handling by predators.

The frequency of injury in an animal population is often cited as a measure of predator-prey interaction, although until recently predation intensity and predator efficiency had not been conceptually distinguished from one another as factors in the injury-causing process. Schoener (*11*) demonstrated that, under certain circumstances, the frequency of occurrence of uninjured animals in a population is proportional to the efficiency of the predators and is largely independent of the intensity of predation. Schoener's method was used to estimate both predator efficiency (experimental, 0.72; control, 0.65) and predation intensity (experimental, 0.88; control, 1.18) for the two groups of butterflies. No significant difference was noted between experimental and control groups in efficiency ($P > .5$), but predation intensity appeared to be slightly greater for controls ($.10 > P > .05$).

Of all Lepidoptera tested, *Anartia* butterflies are among the most palatable to predators and have been widely used as control food items in experiments on warning coloration and mimicry (*4*, *12*). The few observations of predation in nature by birds, lizards, and arthropods confirm these laboratory findings.

Wing patterns with broad contrasting vertical stripes occur in most families of butterflies (Fig. 1A) and in some diurnal moths. They are rare or absent among chemically "protected," unpalatable species. Such patterns have frequently been cited as examples of disruptive coloration (for example, in *Limenitis a. arthemis*) [(*13*) and Fig. 1A]. Yet *A. fatima* does not appear to be protected from visually oriented predators by its striped coloration (*14, 15*).

Few concepts in the theory of adaptive coloration are as well accepted, but as poorly documented, as that of disruptive coloration. No direct experimental tests demonstrating its efficacy have yet been performed. We are reluctant to cast doubt on this logical general concept from the results of a single experiment, but consider it important to point to the need for caution in interpreting animal coloration from untested hypotheses.

ROBERT E. SILBERGLIED*
ANNETTE AIELLO*
DONALD M. WINDSOR
Smithsonian Tropical Research Institute, Box 2072, Balboa, Republic of Panama

References and Notes

1. H. B. Cott, *Adaptive Coloration in Animals* (Methuen, London, 1957), pp. 47-67; J. P. Hailman, *Optical Signals: Animal Communication and Light* (Indiana Univ. Press, Bloomington, 1977), pp. 164-166.
2. A. M. Young and D. Stein, *Contrib. Biol. Geol. Milwaukee Publ. Mus. 8* (1976).
3. T. C. Emmel, *Evolution* **26**, 96 (1972).
4. R. E. Silberglied, A. Aiello, G. Lamas, *Psyche*, in press.
5. P. R. Ehrlich and S. E. Davidson, *J. Lepid. Soc.* **14**, 227 (1960); we used a modification of this technique involving small inconspicuous spots at the wing bases.
6. Age is determined by subtracting the date on which a butterfly was first captured from the date in question. Longevity is the difference between the dates of the first and last captures. Both age and longevity really refer to residence time in the population, since it is not possible to distinguish emigration from death as causes of disappearance.
7. G. A. F. Seber, *The Estimation of Animal Abundance and Related Parameters* (Hafner, New York, 1973), and references therein. Results reported here are derived directly from the raw data. Since we were sampling efficiently from a relatively small population (with recapture rates on many occasions reaching 100 percent of all individuals known to be present), some of the assumptions underlying "standard" estimates of population size are violated. Although population estimates and variances calculated from these models (Jolly-Seber, Manly-Parr) are not quite appropriate in our case, they were calculated for comparison. No differences in the experimental results or interpretations can be derived from these estimates, which are available on request.
8. General condition refers to the overall extent of wear on individuals; it is a subjective measure of how old a butterfly looks, taking both scale loss and marginal fraying into account. Four states are recognized: excellent (no evident wear), good (slight wear), fair (considerable wear), and poor (extensive wear and fraying). General condition is estimated independent of wing damage.
9. *Anartia fatima* has brittle wings that break and tear upon seizure. Bill marks, scars in the uniform ordering of wing scales characteristic of other butterflies, are not produced; the wing membrane is notched or clipped instead. Symmetrical notching or clipping of the left and right wings is the most common general category of damage; it occurs suddenly and is not due to gradual wing wear. Damage was coded separately for each of the four wings, with a system that described both location and type of damage.
10. We are confident that none of the animals chosen for the experiment were more than 1 week old when first captured. The greatest extent of wing damage, in an experimental or control animal at first capture, was one slight nick in one wing margin (three individuals).
11. T. W. Schoener, *Ecology*, in press.
12. J. Alcock, *Anim. Behav.* **17**, 652 (1969); T. C. Boyden, *Evolution* **30**, 73 (1976); L. P. Brower and J. v. Z. Brower, *Zoologica (N.Y.)* **49**, 137 (1964); L. P. Brower, J. Alcock, J. v. Z. Brower, in *Ecological Genetics and Evolution*, R. Creed, Ed. (Blackwell, Oxford, 1971); R. P. Coppinger, *Behaviour* **25**, 45 (1969); *Am. Nat.* **104**, 323 (1970). Potential vertebrate predators of adult *A. fatima* on Barro Colorado Island include insectivorous birds [E. O. Willis and E. Eisenman, *Smithson. Contrib. Zool. 291* (1979)] and lizards [C. W. Myers and A. S. Rand, *Smithson. Contrib. Zool. 10* (1969)].
13. A. P. Platt, *Evolution* **29**, 120 (1975); _____ and L. P. Brower, *ibid.* **22**, 699 (1968); M. Edmunds, *Defense in Animals* (Longman Group, Essex, 1974), pp. 102-104.
14. Alternative roles for the bands of *A. fatima*, not exclusive of a protective role, include that of a social signal used during courtship (*3*). The light bands vary from yellow to white and change color with age [O. R. Taylor, Jr., *Evolution* **27**, 161 (1973)]. Further experiments on color change and courtship will be reported elsewhere.
15. Five (5.2 percent) experimental and five control individuals were captured by a nonvisual predator, a strategically located female orb-weaving spider (*Argiope argentata*, Araneae), during the course of the study.
16. We thank W. H. Bossert, W. J. Glynn, D. K. Pickard, R. Robbins, and J. M. Sigda for statistical advice, numerous colleagues for helpful suggestions, and the Smithsonian Tropical Research Institute for support and the use of facilities.
* Present address: Museum of Comparative Zoology, Harvard University, Cambridge, Mass. 02138.

18 January 1980; revised 15 April 1980

Fetal Exposure to Narcotics: Neonatal Sleep as a Measure of Nervous System Disturbance

Abstract. *Newborn infants, chronically exposed in utero to low doses of methadone with or without concomitant heroin, display more rapid eye movement sleep and less quiet sleep than control infants, while babies fetally exposed to both opiates and nonopiates have less organization of sleep states. Other perinatal factors, such as birth weight and gestational age, are related more to the amount of fetal drug exposure than to the type.*

Since 1965, when the synthetic opioid methadone became an accepted treatment for heroin addiction, thousands of methadone-treated, heroin-dependent women have given birth. Evidence that opioids such as heroin and methadone cross the placental barrier suggests that chronic use of narcotics by women during pregnancy increases the probability that the fetus will become physically dependent (*1*). Soon after birth, the neonate is likely to display clinical symptoms of opiate withdrawal, including agitated behavioral states, hypertonicity, tremors, and irritability. Studies of this narcotic abstinence syndrome in neonates have generally focused on its clinical characteristics and management, finding considerable individual differences in the onset, variety, intensity, and duration of the behavioral symptoms (*2*).

Psychophysiological assessment of sleep states is an objective measure of nervous system disturbance, offering a potentially useful index of the severity and time course of narcotic withdrawal in neonates. It has not, however, been commonly employed in studies of neonatal withdrawal, despite reports that heroin- and methadone-dependent adults undergoing withdrawal have increased amounts of rapid eye movement (REM) sleep (*3*). Although a similar finding has been confirmed for newborns of untreated heroin-addicted women (*4*), and claimed for newborns of women maintained on methadone (*5*), a recent study reported a decrease in REM in newborns exposed to heroin and methadone in utero (*6*). Consequently, the precise nature of sleep disturbance during narcotic withdrawal in neonates remains unclear; there is no information on whether neonates have different sleep state alterations after fetal exposure to low doses of methadone or various doses of opiates and other drugs. Nor is it known how the degree of sleep state disturbance is related to other perinatal outcomes. We sought to clarify the nature of sleep states and perinatal outcomes during narcotic withdrawal in neonates by taking into account the actual fetal drug exposure resulting from various drug-intake patterns in methadone-treated, heroin-dependent women.

The study involved 58 newborns and their mothers. Twenty-eight of the neonates were the offspring of heroin-dependent women participating in an urban methadone treatment program. These mothers received daily a mean methadone dose of 17.7 mg (range, 2.5 to 35.0 mg). The 30 other newborns were the offspring of control mothers; that is, women who were demographically similar to the drug-dependent women but who did not use drugs. All women received prenatal care and gave birth at the same hospital during a 13-month period. (Each mother's informed consent was first obtained for the study.)